**Dual purpose crops for human food and animal feed.**

**Comparative analysis of improved and local varieties of Sorghum and cowpea under farmer conditions.**

## **Abstract**

Participatory farmer trials were conducted with an objective to test the performance for grain and fodder yield of local and improved varieties of sorghum and cowpea under farmer conditions using farmer techniques to evaluate the fodder quality along with mineral contents in the grains to address the issues in dry season feeding. The treatments(T) were: T1 : farmer preferred local variety of sorghum ; T2 : Improved dual purpose sorghum ; T3 : Farmer preferred local variety of cowpea and T4 : Improved variety of cowpea. Random block design was used. Data on non destructive and destructive agronomic observations were collected on crop performance. Further, a total of 26 grain samples were collected of sorghum for X- Ray Fluorescence analyzer (XRF) for non- destructive method for analysing mineral nutrient contents from grain, for Zinc and Iron content in sorghum grains at ICRISAT laboratory. In addition 72 crop samples in duplicate of sorghum and cowpea were analysed for fodder quality with wet lab analysis on proximate principles in IER Sotuba, where also the samples were processed for analysis at ILRI laboratory for fodder quality analysis using Near Infrared Spectroscopy(NIRS) for nitrogen, neutral (NDF) and acid (ADF) detergent fiber, acid detergent lignin (ADL), in vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) content. Collected data was analysed using ANOVA. Results indicated that farmers preferred local variety for sorghum was Gnodjonani and introduced improved dual purpose variety of sorghum was Fadda. In case of cowpea –farmer preferred cowpea variety was Kadochoni, while introduced improved variety was Dounanfana and these both were primarily grown for the fodder. This introduction of improved varieties has helped the farmers by having more options of variety in their village of crop germplasm. Fadda had significant (p<0.05) results in terms of parameters like days to maturity, days to flowering, and panicle weight indicating it being an early variety with high grain yield and less fodder yield. Local sorghum Gnodjonani had significantly (p<0.05) higher fodder yield and superior fodder quality traits than the improved dual purpose variety Fadda

Cowpea forage yields were more in village Dieba for improved variety Dounanfana(139 g/plot) than local- Kadochoni(105g/plot), similar was the case for village Flola but with lesser yields as compared with village Djeba (improved cowpea-97 g/plot) and local cowpea- 90 g/plot There were no siginficant results on performance of destructive and non destructive observations for both cowpea varieties. Dounanfana had higher forage yields in both villages Dieba (139 g/m2>104.55g/m2)and Flola (96.90g/m2 >89.59g/m2). Kadochoni was early maturing (110<128 days) than improved. Local cowpea variety in village Flola had significantly (p<0.05) higher fodder quality traits (p<0.05) for ME (9.08>8.5) and IVOMD (62.8>59.6) than improved cowpea. In conclusion, in terms of human consumption, with no negative grain penalty farmers have the option to plant Fadda. Findings suggest more delving is required for dual purpose traits such as stover and haulm fodder quantity and quality into crop improvement.

**Keywords** : Dual purpose, fodder quality, cowpea, sorghum and farmer participatory trial

**Introduction:**

Cereal and legumes are highly desirable quality livestock feeds but are currently greatly underutilized and often poorly managed. Often in case of dry arid lands, availability of feeds and fodder is limited. Feed variability is an issue and crop-residues are found in plenty and yet mis- managed leads to increase pressure on biomass. Quality, quantity and seasonality of the feeds poses important constraint in livestock feeding. Concurrently small scale crop-livestock farmers are finding difficulties in providing through enough high quality forage for their animals. This scenario provides an exciting opportunity for greater emphasis on dual purpose crops to meet the future challenges of increasing productivity. There is no doubt that in future food and feed production will have to be met through increased productivity per unit area. For example dual purpose crops can provide grain for human consumption and residues for livestock nutrition from the same land area with similar amount of inputs including water. As with rapid urbanization and growing population decreasing farm sizes, mostly farmers prioritize to cultivate their farm lands for staple food production than for cultivating livestock feeds and forages, it is clear that the croplands must provide the feed resources, therefore for increased population dual purpose crops must deliver to the dual requirement of human and livestock nutrition. As cereal crops and legumes play a substantial role in the nutrition of livestock throughout the Sudano-Sahelien zone of Africa. Quality of local and improved varieties, yields, disease resistance and mineral content in grain should also be an important consideration of their value and distinction; whilst a wide range of cereals and legumes in particular have traditionally provided both grain and fodder, research focus has begun to shift towards improving the productivity, quality and feeding systems of crop residues. (Blummel *et al*., 2003, Lenne and Thomas 2006). There is also a need to provide information on farmer preferred local germplasm, as it gives base material for breeders for making new varieties with preferred traits.

Keeping this reasons, a participatory farmer trial was planned with an objective to test the performance for grain and fodder yield of local and improved varieties of sorghum and cowpea under farmer conditions using farmer techniques to evaluate its impact on the grain and fodder yields.

**Methodology:**

**The treatments were as follows:**

T1: farmer preferred local variety of sorghum: T2: Improved dual purpose sorghum; T3 : Farmer preferred local variety of cowpea and T4 : Improved variety of cowpea. Random block design was used. Three farmers were selected for four treatments and for each treatment 3 farmers acted as 3 replication.

Farmer selection criteria:

1. Those farmers will be selected who are willing to participate in the trial. This a total of 12 farmers from two villages of Flola and Djeba of Bougouni district volunteered and participated in the trial.
2. Living the villages of action sites
3. Preference was given for inclusion of women farmers

Conditions and protocols followed by the selected farmers

1. Variety was same in all replications for improved seed of sorghum in all treatments and same variety of local sorghum in all treatments. Similar was the case for cowpea improved and local varieties.
2. Sowing time in all the plots were the same
3. Seed rate , manure application, intercultural operation were the same
4. Harvest time were the same.
5. The farmer kept the fodder/crop-residue for animal feeding trial next year from the crop trial

Apart from that from every farmer field, samples were taken for grains and stovers in case of sorghum, and haulms only for cowpea. The fodder samples were analyzed for grain (sorghum only) and fodder quality for wet lab analysis on proximate principles to IER Sotuba, where the samples were processed for ILRI for fodder quality analysis by Near Infrared Spectroscopy for nitrogen, neutral (NDF) and acid (ADF) detergent fiber, acid detergent lignin (ADL), in vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) content. Data was analyzed using ANOVA.

**Results and Discussion**

Planning workshops were held by the participating farmers in the village of Fiola, Sibirila and Djeba of district Bougouni to know farmer needs on crop preference, number of participating farmers and inputs requirement like seeds, manure, fertilizer requirement etc. Thus a total of 12 farmers volunteered for the trial in Sorghum while 8 for cowpea.

Table 1: Location of the farmer participatory trials:

|  |  |  |
| --- | --- | --- |
| Location | Mali | Mali |
| District | Bougouni | Bougouni |
| Commune | Kouroulamini | Danou |
| Village(s) | Flola | Djeba |
| Coordinates | Lat: 11.42 Long −7.64 | Lat :11.51; Long: −7.93 |
| Total Population | 465 | 1121 |
| Male | 219 | 533 |
| Female | 246 | 588 |
| Crop(s) | Sorghum, Cowpea | Sorghum, Cowpea |
| Names of sorghum varieties | Gnodjonani, Fadda | Gnodjonani, Fadda |
| Names of cowpea varieties | Kadochoni, Dounanfana | Kadochoni, Dounanfana |

One local and one improved variety of sorghum and one local and improved variety of cowpea was selected by the participating farmers.

**Crop performance At Villages Flola and Djeba**

Sorghum: As table 2 below shows that dual purpose Fadda needed significantly (p<0.05) less days to maturity (115<138.8), less days to 50% flowering (80.77<93.92) and had higher panicle weight (33g/m2>29.5g/m2) than Gnodjonani which however had (p<0.05) the higher fodder yield (81.5g/m2 >71.7g/m2). In Djeba village, Fadda had significantly longer panicle length (25.32cm>24.58) than local while in village Flola on number of plants harvested.

Table 2: Comparison of improved Sorghum with local in two villages

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Crops | Fadda | Gnodjonani | P>F | Djeba | Flola | P>F | P>F |
| Parameters | Mean | Mean | In Variety | Mean | Mean | Village | Variety and Village |
| Plant height (m)/plot | 2.110 | 2.018 |  | 2.09 | 2.033 |  |  |
| Panicle length (cm)/plot | 25.32 | 24.58 |  | 23.60 | 26.45 |  | 0.005 |
| Days of Maturity (days)/plot | 115.08 | 138.83 | <.001 | 128.06 | 124.77 |  |  |
| 50% flowering (days)/plot | 80.77 | 93.92 | <.001 | 86.93 | 87.24 |  |  |
| Number of hills/plot) | 562. | 476. |  | 655 | 375 | 001 |  |
| Number of plants/plot | 1206 | 865 | 0.028 | 1116 | 962 |  | 0.018 |
| Number of panicles harvested /plot(g) | 1246. | 936 |  | 1199. | 987 |  | 0.05 |
| Fodder yield/plot(g) | 71.7 | 81.5 | 001 | 33.5 | 122.9 |  |  |
| Panicle weight g/plot | 33.2 | 29.7 | 0.020 | 25.9 | 37.5 |  | 0.053 |
| Striga count/plot | 1.35 | 0.96 |  | 1.57 | 0.72 |  |  |
| At 5% level of significance | | | | | | | |

The table 2 above indicates (p<0.05) Fadda has significant results in terms of parameters like days of maturity, flowering days, and panicle weight. There was significant variation (p<0.05) in, fodder yield and panicle weight for local variety of sorghum had more fodder yield. There was a significant variation (p<0.05) in village for the number of hills per plot. There was a significant variation between variety and village for panicle length, number of plants, number of panicle harvested and panicle weight. Djeba village had better panicle length, while number of plants harvested in Flola were significant.

Table 3: Iron and Zinc content in local and improved sorghum

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Details | Fe total (mg/kg) | S.E | Range | Zn total (mg/kg) | SE | Range |
| Village Flola |  |  |  |  |  |  |
| Local variety Sorghum | 179.4 | 11.43 | 75 | 35.6 | 1.28 | 7.5 |
| Fadda | 248.8 | 17.39 | 105 | 32.5 | 0.79 | 3.75 |
| Village Djeba |  |  |  |  |  |  |
| Local variety Sorghum | 218.6 | 12.23 | 82.5 | 38.0 | 1.51 | 11.25 |
| Fadda | 209.5 | 16.71 | 120 | 26.3 | 3.75 | 22.5 |

As table 3 indicates that the iron content found in Fadda was more than local variety in village Flola, while less in village Djeba. In both locations zinc content was less in improved variety than the local one. This could be perhaps because of different soil conditions. Literature data indicate that the dominant soils in southern Mali are Arenosols, Lixisols and Acrisols( Birhanu and Tabo, 2016). These soils are inherently fragile, low in carbon and poor in plant nutrients (Serigne et al 2006).

Cowpea: In cowpea Kadochoni was local variety and Dounanfana as introduced improved forage variety. Dounanfana had higher forage yields in both villages Dieba (139 g/m2>104.55g/m2)and Flola (96.90g/m2 >89.59g/m2). Kadochoni was early maturing (110<128 days) than improved (table 4).At village Flola, 50% flowering was observed in the case of the variety Dounanfana from the 79th day while in the case of the variety Kadochoni, this observation was effective from 78th day. However in Djeba for those varieties Dounanfana and Kadochoni days to 50% flowering was observed respectively from the 85th and 78th day. Maturity is reached on the 44th day to 50% flowering at Flola for the case of Dounanfana variety corresponding to 123rd DAS while in the case of the Kadochoni variety, maturity was reached at the 118th DAS

Table 4: Performance of cowpea varieties

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Crops | Dounanfana | Kadochoni | Djeba- Village | Dounanfana | Kadochoni | Flola |
| Parameters | Mean | Mean | Mean | Mean | Mean | Mean |
| No. of Plant/Plot | 809.5 | 787.75 | 798.625 | 836 | 778.25 | 807.125 |
| Number of hills/plot) | 512.75 | 525.25 | 519 | 556.25 | 519 | 537.62 |
| Days to Maturity (days)/plot | 84.25 | 77.5 | 80.875 | 78.75 | 77.25 | 78 |
| Days to 50% flowering (days)/plot | 119 | 107 | 113 | 123 | 117.25 | 120.125 |
| Fodder yield/plot(g) | 138.87 | 104.55 | 121.71 | 96.905 | 89.5925 | 93.24875 |

Dounanfana had higher forage yields in both villages Dieba (139 g/m2>104.55g/m2)and Flola (96.90g/m2 >89.59g/m2). Kadochoni was early maturing (110<128 days) than improved (table 3). There were no significant differences observed within varieties, between villages and between variety and villages. Cowpea crop was mostly grown for haulms. There were no significant results on performance of destructive and non-destructive observations for both cowpea varieties.

Table 5: Fodder quality traits in Sorghum at Mali

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fodder quality traits | Flola Village | Dieba Village | Fadda- Improved variety | Local variety | Pr>F | Location | Variety | Location x variety |
| CPDM | 13.90 | 13.51 | 14.15 | 13.26 |  | 0.02 |  |  |
| NDF | 43.75 | 49.67 | 47.36 | 46.07 | <.0001 | <.0001 |  |  |
| ADF | 35.08 | 30.17 | 33.88 | 31.37 | 0.0005 | 0.0001 |  |  |
| ADL | 7.43 | 8.48 | 8.17 | 7.74 | 0.0009 |  | 0.0006 |  |
| ME | 9.08 | 8.57 | 8.62 | 9.03 | 0.0051 | 0.0075 | 0.0274 |  |
| IVOMD | 62.81 | 59.63 | 60.04 | 62.39 | 0.0032 | 0.0016 |  |  |
| Cellulose org | 28.03 | 49.92 | 35.14 | 42.81 | 0.0002 | 0.0007 | 0.0168 | 0.0554 |
| \*NDF-org | 38.98 | 43.56 | 42.77 | 39.77 | 0.0004 | <.0001 |  |  |
| \*Adf-org | 31.07 | 33.06 | 33.68 | 30.45 | 0.0442 | 0.0081 |  |  |
| \*Cp-org | 10.80 | 14.63 | 14.32 | 11.12 |  | 0.0083 |  |  |
| \*Fat-org | 2.05 | 2.06 | 1.96 | 2.15 |  |  |  |  |
| \*kcalkg | 3887.16 | 3819.75 | 3884.40 | 3822.51 |  |  |  |  |
| \*Ca | 0.68 | 0.08 | 0.36 | 0.40 | <.0001 | <.0001 |  | <.0001 |
| \*P | 0.38 | 0.10 | 0.22 | 0.25 | <.0001 | <.0001 | 0.0002 | 0.0003 |

\*Wet lab analysis. The significance is set at P<0.05

Local sorghum variety had significantly higher fodder quality traits in village Flola for ME (7.1>6.6) at (p<0.0075), and IVOMD (46.98>43.26) at (p<0.0016) than Fadda. Local sorghum variety had significantly (p<0.0006) less ADL (6.5<7.11) than Fadda. Results from farmers participatory trials showed that local sorghum Gnodjonani had significantly (p<0.05) higher fodder yield and superior fodder quality traits than the improved dual purpose variety Fadda (table 4). It is now recognised that large number of farmers demand sorghum cultivars with superior grain yield but without sacrifice of good stover quantity and fodder quality (Blümmel et al., 2010). More work is required to improve the quantity and quality aspects in dual purpose crops. Selection for improved crop residue quality (such as sorghum stover) is possible without negative impacts on grain yields and a multidimensional crop improvement approach has been actively integrated into a number of crop breeding programmes (Blümmel et al., 2003) resulting in increased overall productivity of mixed crop livestock system.

Table 6: Fodder quality traits in Cowpea at Mali

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Flola Village** | **Dieba Village** | **Dounanfana** | **Local - Kadochoni** | **Pr>F** | **Location** | **Variety** | **Location x variety** |
| CPDM | 13.90 | 13.51 | 14.15 | 13.12 |  |  |  |  |
| NDF | 49.67 | 43.75 | 47.36 | 46.07 | 0.0002 | <.0001 |  |  |
| ADF | 35.08 | 30.17 | 33.88 | 31.37 | 0.0002 | <.0001 | 0.0094 |  |
| ADL | 8.4 | 7.4 | 8.17 | 7.74 | <.0001 | <.0001 | 0.0033 |  |
| ME | 9.08 | 8.5 | 8.6 | 9.03 | 0.0014 | 0.0022 | 0.0089 | 0.040 |
| IVOMD | 62.81 | 59.63 | 60.04 | 62.39 | 0.0005 | 0.0006 | 0.0051 | 0.037 |
| Cellulose org | 49.92 | 28.03 | 35.14 | 42.81 | 0.002 | 0.0009 |  |  |
| \*NDF-org | 43.56 | 38.98 | 42.77 | 39.77 | 0.0002 | 0.0001 | 0.0033 |  |
| \*Adf-org | 33.06 | 31.07 | 33.68 | 30.45 | 0.0010 | 0.0153 | 0.000 |  |
| \*Cp-org | 14.63 | 10.80 | 14.32 | 11.12 |  |  |  |  |
| \*Fat-org | 2.06 | 2.05 | 1.96 | 2.15 |  |  |  |  |
| \*kcalkg | 3887.16 | 3819.75 | 3884.40 | 3822.51 | 0.02 | 0.04 | 0.05 |  |
| \*Ca | 0.68 | 0.08 | 0.36 | 0.40 | <.0001 | <.0001 |  |  |
| \*P | 0.38 | 0.10 | 0.22 | 0.25 | <.0001 | <.0001 |  | 0.0061 |

Wet lab analysis. The significance is set at P<0.05

As table 6 indicates that the improved cowpea variety had significantly (p<0.05) inferior fodder quality and insignificantly higher fodder yield compared to the local cultivar (table 5).Local cowpea variety in village Flola had significantly (p<0.05) higher fodder quality traits (p<0.05) for ME (9.08>8.5) and IVOMD (62.8>59.6) than improved cowpea. Another point is improved cowpea variety had significantly lesser Ca (0.36<0.40) and P (0.22<0.25) than the local variety. Dunanfana is a cowpea fodder variety is a pure line with cultivar name as PBL 112 released by IRAD (Falconnier, 2016). Perhaps farmers know about the fodder quality among cultivars for livestock performance that could be the reason of growing local cowpea variety if that was not the case merely on the fodder quantity basis adoption of new crop cultivars in mixed crop livestock systems would have been possible. In order to ensure that improved varieties are widely disseminated in the farmers’ communities, it is important that plant breeders be appropriately involved in the transfer process to end-users (Camara *et al.,* 2005). As cowpea varieties only grown for fodder indicate high demand of haulms for livestock feed. Findings suggest more delving is required for dual purpose traits such as stover and haulm fodder quantity and quality into crop improvement.

**References :**

Birhanu and Tabo, R. (2016). Shallow wells, the untapped resource with a potential to improve agriculture and food security in southern Mali Agric & Food Secur 5:5 DOI 10.1186/s40066-016-0054-8

Blümmel, M., Zerbini, E., Reddy, B. V., Hash, C., Bidinger, F., and Khan, A. (2003). Improving the production and utilization of sorghum and pearl millet as livestock feed: progress towards dual-purpose genotypes. F. Crop. Res. 84, 143–158. doi:10.1016/S0378-4290(03)00146-1.

Blümmel, M., Khan, A. A., Vadez, V., Hash, C. T., and Rai, K. N. (2010). Variability in stover quality traits in commercial hybrids of pearl millet (Pennisetum glaucum (L.) R. Br.) and grain - stover trait relationships. Anim. Nutr. Feed Technol. 10, 29–38.

Camara Y, Bantilan MCS and Ndeunga J. 2005. Impacts of sorghum and millet research in West and Central Africa (WCA): A synthesis and lessons learnt. Working Paper Series no. 22. Sahelian Center, BP 12404 Niamey, Niger: International Crops Research Institute for the Semi-Arid Tropics. 48 pp. <http://oar.icrisat.org/3807/1/SEP_WPS22.pdf>

Lenné, J. M., and Thomas, D. (2006). Integrating crop-livestock research and development in Sub-Saharan Africa: Option, imperative or impossible? Outlook Agric. 35, 167–175. doi:10.5367/000000006778536765.

Falconnier, GN. 2016. Trajectories of agricultural change in southern Mali. PhD Thesis, Wageningen University, Wageningen Netherland.

Serigne, T.K., Louis, V., Jens, M. (2006). Climate change and variability in the Sahel region: impacts and adaptation strategies in the agricultural sector. A document produced by Word Agroforestry Centre (ICRAF), and the United Nations Environment Programme (UNEP); 2006. pp 58. https:// [www.scribd.com/doc/299921544/Climate-Change](http://www.scribd.com/doc/299921544/Climate-Change).